the other two had deep red blotches which persisted for several months.[6]

In a more exact study, six men were selected for the test which was run with a 0.5% mustard gas control. The mustard gas caused a blister on all subjects, while our chlorosulfide was negative up to 2%. A 3% solution caused redness and slight itching. A 5% solution caused a blister which was equal in nearly every case to the blister caused by a 0.5% solution of mustard gas. It also caused itching comparable to mustard gas. Carbon tetrachloride was used as a solvent for both compounds. It is quite probable that the furfuryl sulfide is more effective than these results indicate, because the tests were carried out with a sample that had undergone partial decomposition. Because of this decomposition no toxicity tests were made.

The authors wish to thank the Miner Laboratories of Chicago for liberal supplies of furfural, and those who helped carry out the several tests.

## Summary

Directions are given for the preparation of β-chloro-ethyl furfuryl sulfide and γ-chloropropyl furfuryl sulfide in good yields. The β-compound in agreement with other results has a pronounced vesicant action, whereas the γ-chlorosulfide is without vesicant action.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF IOWA STATE COLLEGE]

# ALPHA-METHYL-GAMMA-TETRAHYDRO-2-FURYLPROPYLMAGNESIUM BROMIDE

BY HENRY GILMAN AND JOSEPH B. DICKEY

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## Introduction

In extension of studies concerned with furan compounds, it was quite natural for us to turn to the preparation of organomagnesium halides synthesized from furan types, primarily with a view to an interpretation of other furan reactions. An astonishingly small number of such investigations has been made, undoubtedly because of the inaccessibility of halogen furan compounds and the relative inertness of the halogen in many of these compounds. Moureu, Dufraisse and Johnson[1] prepared furylacetenylmagnesium bromide $C_4H_3OC{\equiv}CMgBr$, by an indirect method in-

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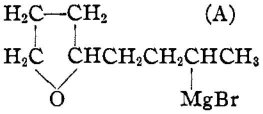
[6] Some tests were carried out with the assistance of Professor M. D. Helser (to whom grateful acknowledgments are made) on hogs, in connection with the possible utility of these and other compounds for the marking of hogs. When applied in undiluted form to the skin of hogs twelve hours before killing, intense red spots remained on the skin of the animals after removal from the depilatory bath. However, no blisters developed.

[1] Moureu, Dufraisse and Johnson, *Ann. chim.*, **7**, 1 (1927).

volving the reaction between ethylmagnesium bromide and furylacetylene, which is prepared with unusual difficulty and in depressingly low yields after a series of transformations. Allen and Rosener[2] were unsuccessful in their attempts to prepare a Grignard reagent from 2,3,5-triphenyl-4-bromofuran. This is understandable in view of the extreme inertness of the bromine even toward hot alcoholic potash. Fenton and Gostling[3] reported no appreciable reaction between 5-bromomethylfurfural and magnesium in benzene.

The organomagnesium halide which we have prepared is readily obtainable by standard reactions which start with furfural. This aldehyde is condensed to furfuralacetone,[4] which is then catalytically reduced by the method of Kaufmann and Adams[5] to α-methyl-γ-tetrahydro-2-furylpropanol. There was no difficulty in converting this carbinol to the corresponding bromide, and the Grignard reagent is prepared from the bromide with great ease and in excellent yields (94%). The organomagnesium halide so prepared, α-methyl-γ-tetrahydro-2-furylpropylmagnesium bromide (A) has been characterized by appropriate derivatives.


(A)

## Experimental Part

The furfuralacetone, prepared after the directions of Leuck and Cejka,[4] was obtained in the yields described by them. However, we could not equal the yields described for the preparation of α-methyl-γ-tetrahydro-2-furylpropanol. Our yields varied from 15 to 25% when 55.0 g. (0.404 mole) of furfuralacetone in 150 cc. of 95% ethyl alcohol was catalytically reduced with 1.0 g. of the platinum catalyst. Several runs were made with varying small quantities of ferrous chloride as a promoter, but there was no essential alteration in yield. The promoter was tried in the hope that the catalytic reduction, which proceeds with ease, might be restricted, because it is possible to have a miscellany of reduction products with a compound like furfuralacetone. Possibly a part of our difficulty lies in incomplete fractionation. Whatever the cause, it is very gratifying to report that unpublished results on the catalytic reduction of furylacrolein by the method of Adams and Bray[6] have consistently given yields which are several per cent. in excess of those reported by them. In this latter reduction, absolute ethyl alcohol was used as the medium, and there is a possibility that such alcohol might improve the yield of α-methyl-γ-tetrahydro-2-furylpropanol. The ready accessibility of α-tetrahydro-2-furylpropanol, the high yields of chloride from this, and the high yields of Grignard reagent from the chloride make this a better organomagnesium halide for synthetic purposes.

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[2] Allen and Rosener, THIS JOURNAL, **49**, 2110 (1927).

[3] Fenton and Gostling, *J. Chem. Soc.*, **79**, 807 (1900).

[4] Leuck and Cejka, "Organic Syntheses," John Wiley and Sons, Inc., New York, **1927**, Vol. VII, p. 42.

[5] Kaufmann and Adams, THIS JOURNAL, **45**, 3029 (1923).

[6] Adams and Bray, *ibid.*, **49**, 2101 (1927).

**Benzoate of α-Methyl-γ-Tetrahydro-2-Furyl-Propanol,** $C_4H_7OCH_2CH_2CH(CH_3)OCOC_6H_5$.—The butanol was characterized by the preparation of the benzoate. This ester was obtained in a 72% yield by refluxing the carbinol with benzoyl chloride in benzene. It is a colorless, stable liquid, with a sharp taste and with no appreciable odor. The boiling point is 164–166° (3 mm.).

*Anal.* Calcd. for $C_{15}H_{20}O_3$: C, 72.53; H, 8.12. Found: C, 72.20, 72.35; H, 8.05, 8.02.

**α-Methyl-γ-tetrahydro-2-furylpropyl Bromide,** $C_4H_7OCH_2CH_2CH(CH_3)Br$.—This bromide was obtained in a 59.8% yield by saturating a solution of 20.4 g. (0.141 mole) of the carbinol in 20 cc. of anhydrous benzene with hydrogen bromide.[7] The bromide distils at 79.5–80° (4 mm.) as a clear, colorless liquid, of sweet odor and sharp taste. It is insoluble in water, but soluble in the more common organic solvents; $d_{20}^{20}$ 1.2000; $n_D^{20}$ 1.4719.

*Anal.* Calcd. for $C_8H_{15}OBr$: Br, 38.6. Found: Br, 38.03, 38.10.

**α-Methyl-γ-tetrahydro-2-furylpropylmagnesium Bromide,** $C_4H_7OCH_2CH_2CH(CH_3)MgBr$.—Following the directions of Gilman, Zoellner and Dickey,[8] the reaction was started by adding a few drops of the undiluted bromide and a crystal of iodine to 2.39 g. (0.0986 atom) of 30–80 mesh magnesium in 10 cc. of ether. Then the remainder of the bromide, totaling 18.5 g. (0.0896 mole) in 35 cc. of ether was added over a period of one and one-half hours. Subsequent to addition of the halide, the mixture was refluxed for one hour. Titration by the method of Gilman, Wilkinson, Fishel and Meyers[9] showed the yield to be 91.5%. In another experiment of 0.02 mole size, the yield was 94%.

The Grignard solution gave a beautiful blue color when a small aliquot was treated after the color test directions of Gilman, Schulze and Heck[10] for reactive organometallic compounds.

**α-Methyl-γ-tetrahydro-2-furyl-butyro-α-Naphthalide,** $C_4H_7OCH_2CH_2CH(CH_3)CONHC_{10}H_7$-α.[11]—The α-naphthalide was prepared in accordance with the directions of Gilman and Furry[12] from the Grignard reagent and α-naphthylisocyanate. It melts[13] at 109.5–110°.

*Anal.* Calcd. for $C_{19}H_{23}O_2N$: C, 76.72; H, 7.77. Found: C, 76.06, 76.00; H, 8.29, 8.23.

**α-Methyl-γ-tetrahydro-2-furylbutyric Acid,** $C_4H_7OCH_2CH_2CH(CH_3)CO_2H$.—The acid was prepared by the carbonation of the organomagnesium bromide, in accordance with the directions of Gilman and Parker.[14] The yield of pure acid, distilling at 104–106° (0.2–0.3 mm.), was 59% (calculated on the RMgBr compound). It is a water-

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[7] No study was made of optimal conditions for the preparation of the bromide. Because our chief interest was to procure the bromide free of carbinol, this saturation was extended over several days. Unquestionably the time can be drastically reduced because the first saturation, in a cooling mixture, was accompanied by a somewhat vigorous reaction.

[8] Gilman, Zoellner and Dickey, THIS JOURNAL, **51**, 1576 (1929).

[9] Gilman, Wilkinson, Fishel and Meyers, *ibid.*, **45**, 150 (1923).

[10] Gilman and Schulze, *ibid.*, **47**, 2002 (1925); *Bull. soc. chim.*, **41**, 1479 (1927). Gilman and Heck, *Rec. trav. chim.*, **48**, 193 (1929); *Ber.*, **62**, 1379 (1929).

[11] The authors are indebted to Nina B. St. John for the preparation of this compound.

[12] Gilman and Furry, THIS JOURNAL, **50**, 1214 (1928).

[13] The temperatures recorded in this paper are uncorrected.

[14] Gilman and Parker, THIS JOURNAL, **46**, 2816 (1924).

white, stable liquid of a sharp taste and disagreeable odor, and is slightly soluble in water; $d_{20}^{20}$ 1.0401; $n_D^{20}$ 1.4528.

*Anal.* Calcd. for $C_9H_{16}O_3$: C, 62.74; H, 9.37. Found: C, 62.50, 62.35; H, 9.50, 9.46.

## Summary

α-Methyl-γ-tetrahydro-2-furylpropylmagnesium bromide is obtainable in excellent yields from the corresponding bromide which is accessible, in turn, from furfural. This organomagnesium halide is one of the unusually small number of the furan type so far reported, and probably the first to be obtained by a direct reaction. It has been characterized by appropriate derivatives.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, NEW YORK UNIVERSITY, AT WASHINGTON SQUARE COLLEGE]

# CRYSTALLINE MONOMETHYLDIETHYLMERCAPTOGLUCOSE

BY PHILIPPOS E. PAPADAKIS

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The author has had occasion to prepare pentamethyldiethylmercaptoglucose using Fischer's[1] method for the formation of diethylmercaptoglucose and a combination of Haworth[2] and Freudenberg's methods for the methylation process as described by Levene and Meyer.[3]

In some experiments, instead of following Levene and Meyer's procedure, which favors the formation of the polymethylated product, the following method was adopted. The dimethyl sulfate, three times the required amount, was placed in a three-necked flask; the flask was provided with an efficient stirrer, a reflux condenser and a large separatory funnel; the diethylmercaptoglucose was suspended in the sodium hydroxide, which was placed in the separatory funnel, and thence was allowed to flow into the flask gradually. The temperature was kept at 67°.

The methylated product was extracted by ether. After the ether was evaporated the remaining brown sirup which was supposed to contain the polymethylated product was very little in quantity. From the brown sirup, however, a crystalline substance was obtained which was recrystallized from absolute alcohol and gave a melting point of 156°. These crystals were kept for future reference.

Besides these crystals it was observed that during the ether extraction a solid substance was going into suspension in the ether layer. From this solid substance some unmethylated mercaptoglucose was extracted by boiling ether. The residue had a melting point between 155 and 160°.

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[1] E. Fischer, *Ber.*, **27**, 673 (1894).

[2] W. N. Haworth, *J. Chem. Soc.*, **107**, 11 (1915).

[3] Levene and Meyer, *J. Biol. Chem.*, **67**, **176 (1926)**.